

Chapter 12: Chemical analysis

Knowledge organiser

Pure and impure

In chemistry, a **pure** substance contains a single element or compound that is not mixed with any other substance.

Pure substances melt and boil at specific temperatures.

An **impure** substance contains more than one type of element or compound in a **mixture**.

Impure substances melt and boil at a range of temperatures.

Formulations

Formulations are examples of mixtures. They have many different components (substances that make them up) in very specific proportions (amounts compared to each other).

Scientists spend a lot of time trying to get the right components in the right proportions to make the most useful product.

Formulations include fuels, cleaning agents, paints, alloys, fertilisers, and foods.

Testing gases

Common gases can be identified using the following tests:

Gas	What you do	What you observe if gas is present
hydrogen	hold a lighted splint near the gas	hear a squeaky pop
oxygen	hold a glowing splint near the gas	splint re-lights
carbon dioxide	bubble the gas through limewater	the limewater turns milky (cloudy white)
chlorine	hold a piece of damp litmus near the gas	bleaches the litmus white

Flame tests

Substances containing metals can produce a coloured light in a flame. This can be used to identify the metal. However, if there is more than one metal in the substance then this method will not work, as the colours mix and intense colours mask more subtle colours.

Metal	Flame colour
lithium	crimson
sodium	yellow
potassium	lilac
calcium	orange-red
copper	green

Instrumental methods

Instrumental analysis involves using complex scientific equipment to test substances.

Instrumental methods are rapid and accurate. They are also sensitive, which means they can give results even with very small amounts of substance.

Flame emission spectroscopy

Flame emission spectroscopy is a type of instrumental analysis similar to a **flame test**.

The sample solution is put into a flame and the light given off is passed through a spectroscope. Instead of a human observing a colour, the instrument tells you exactly which wavelength of light is being given off as a line spectrum. You can then compare the spectrum to a reference to establish the identity of your sample. You can also measure the concentration of the substance in your sample solution.

Chromatography

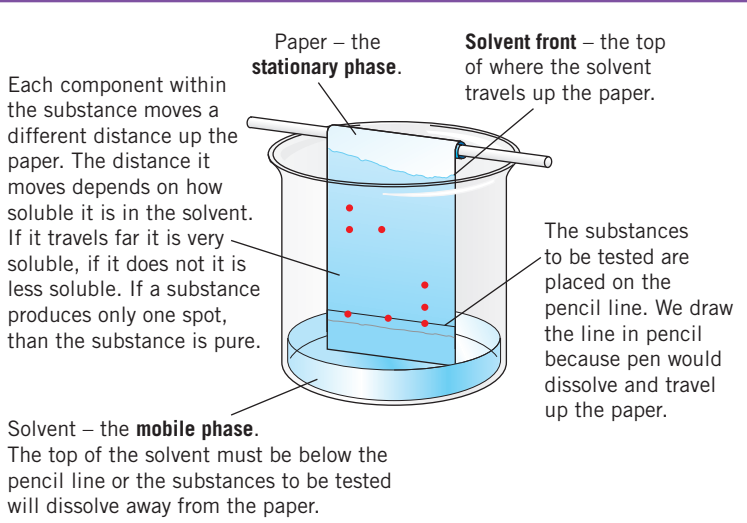
Chromatography is a method to separate different components in a mixture. It is set up as shown here, with a piece of paper in a beaker containing a small amount of solvent.

The **R_f value** is a ratio of how far up the paper a certain spot moves compared to how far the **solvent** has travelled.

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

It will always be a number between 0 and 1.

The **R_f value** depends on the solvent and the temperature, and different substances will have different **R_f values**. The **R_f values** for particular solvents can be used to identify a substance.



Testing for cations

Metal ions always have a positive charge (i.e., they are cations). Sodium hydroxide solution can be used to identify some metal ions.

Cation	Positive result
aluminium ions, Al ³⁺	on slow addition of excess sodium hydroxide solution, white precipitate forms that eventually dissolves again with excess sodium hydroxide
calcium ions, Ca ²⁺	on addition of excess sodium hydroxide solution, white precipitate that does not dissolve
magnesium ions, Mg ²⁺	on addition of excess sodium hydroxide solution, white precipitate that does not dissolve
copper(II) ions, Cu ²⁺	forms a blue precipitate
iron(II) ions, Fe ²⁺	forms a green precipitate
iron(III) ions, Fe ³⁺	forms a brown precipitate

Testing for anions

Anion	Test	Positive result
carbonate, CO ₃ ²⁻	add dilute acid	carbon dioxide gas formed which can be test for with limewater
chloride, Cl ⁻	add silver nitrate solution in the presence of nitric acid	white precipitate formed
bromide, Br ⁻	add silver nitrate solution in the presence of nitric acid	cream precipitate formed
iodide, I ⁻	add silver nitrate solution in the presence of nitric acid	yellow precipitate formed
sulfate, SO ₄ ²⁻	add barium chloride solution in the presence of hydrochloric acid	white precipitate formed



Key terms

Make sure you can write a definition for these key terms.

chromatography

mobile phase

flame emission spectroscopy

precipitate

pure

flame test

R_f value

formulation

solvent

impure

solvent front

instrumental analysis

stationary phase